LEGUMES

Growth and Development of Hairy Vetch Cultivars in the Northeastern United States as Influenced by Planting and Harvesting Date

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ABSTRACT

Hairy vetch (*Vicia villosa* Roth) is a winter annual legume that has become an important cover crop for sustainable production systems. New cultivars of hairy vetch, developed in the southern United States, need to be tested as cover crops in the northeastern states. Research was conducted at three locations (Salisbury, MD; Beltsville, MD; and Freeville, NY) that represent a range from a relatively mild coastal climate to a colder interior climate. Four cultivars of hairy vetch (common and three cultivars developed at Auburn University, AU Early Cover, Advanced Population 8, and Advanced Population 26) were planted at either optimum or delayed dates, and biomass was harvested when either vegetative or flowering. Common hairy vetch biomass was equal to or higher than the Auburn cultivars at all locations and years. The Auburn cultivars were winter hardy under Maryland but not under New York conditions. The Auburn cultivars reached 50% flowering an average of 15 d earlier than common hairy vetch. Delaying planting by 2 to 3 wk reduced hairy vetch biomass by 43% when harvested vegetative and by 20% when harvested at flowering. Hairy vetch growth and development could be predicted on the basis of growing degree days (GDD) with a base temperature of 4°C. The biomass of common hairy vetch increased linearly by 41 g m^{-2} for every 100 GDD, and there was no significant difference in the slope of biomass gain between cultivars. Results suggest that the Auburn cultivars are an alternative for Maryland growers desiring a legume cover crop that flowers earlier than common hairy vetch but that delayed planting may compromise adequate winter ground cover and spring biomass regardless of cultivar.

Hairy vetch is a winter annual legume that has become an important cover crop for sustainable production systems. It is winter hardy in most areas of the United States except northern border states such as Maine where winterkill has been reported (Jannink et al., 1997). When used as a cover crop, hairy vetch is typically planted in late summer or early fall after summer crops are harvested. Hairy vetch is adapted to planting at this time of year because the optimum germination temperature ranges from 15 to 23°C (Brar et al., 1991; Mosjidis and Zhang, 1995), and the optimum temperature for early root growth is 20 to 25°C (Mosjidis and Zhang, 1995). It is adapted to growth in early spring because the soil temperature for optimum growth, water use efficiency, and N fixation is 10°C when air temperature is 20°C (Zachariassen and Power, 1991; Power and Zachariassen, 1993). Abundant lateral growth by vines in spring allows hairy vetch to compensate for sparsely covered areas and to provide almost complete ground cover by the time summer crops are planted. Because of high biomass production and high N content, a hairy vetch cover crop can contribute most of the N needs of high-N-requiring crops such as corn (*Zea mays* L.; Decker et al., 1994) or tomato (*Lycopersicon esculentum* Mill.; Abdul-Baki et al., 1997). The mulch left after hairy vetch is killed in no-tillage systems will protect the soil from erosion, improve conservation of soil moisture during summer months (Clark et al., 1995), and suppress weeds (Teasdale and Rosecrance, 2003).

The choice of planting date for a hairy vetch cover crop is influenced by the previous crop and the timing of when that crop is planted and harvested. Experience suggests that hairy vetch should be planted by late September in Maryland or by late August in New York to achieve reliable performance. However, the time of harvesting a summer crop can vary considerably depending on the crop species (e.g., vegetable vs. grain crop) and the plant parts to be harvested (e.g., corn harvested for silage vs. grain). Late harvesting or inclement weather may delay the timing of hairy vetch planting operations past optimum. More precise information is needed on the optimum time to plant hairy vetch and the consequences of delayed planting dates.

The timing for killing hairy vetch in spring can influence hairy vetch performance, particularly during April and May when the growth rate accelerates. Delaying the kill date by approximately 2 wk between late April and early May increased biomass production by 61% in North Carolina (Wagger, 1989) and 35% in Maryland (Clark et al., 1995). Clark et al. (1995) showed that delaying the kill date to late April or early May was preferable for growing corn because the additional hairy vetch biomass had a higher N content and better protected soil moisture from evaporation. In addition, delaying the hairy vetch kill date may compensate for growth lost by delayed planting in fall. The optimum time for killing hairy vetch may be more flexible for vegetable crop producers who can wait for warmer conditions to plant their crops than can corn producers.

Hairy vetch is relatively easy to kill by mechanical methods such as mowing or rolling when flowering, but it often recovers and continues growing when these implements are applied to vegetative stands (Creamer and Dabney, 2002; Teasdale and Rosecrance, 2003). This

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Abbreviations: GDD, growing degree days.

requires growers that rely on mechanical means for killing hairy vetch in a no-tillage system to delay planting operations until hairy vetch is flowering. Common hairy vetch that is available commercially flowers later than is convenient for many of these growers to plant. A new cultivar of hairy vetch, AU Early Cover, flowers earlier than common hairy vetch (Mosjidis et al., 1995). This earlier-maturing cultivar could provide growers additional flexibility for killing hairy vetch and planting cash crops at an earlier date. However, AU Early Cover has been shown to have less winter hardiness than other hairy vetch cultivars in Norway (Brandsæter and Netland, 1999). The adaptability of AU Early Cover hairy vetch in the northeastern United States should be determined.

This research was conducted to determine the influence of (i) three locations in the northeastern United States ranging from coastal Maryland to central New York; (ii) two planting dates, optimum or delayed; and (iii) two harvesting dates associated with potential growth stages when the cover crop would be killed, vegetative or flowering, on the performance of common and three early maturing hairy vetch cultivars.

MATERIALS AND METHODS

Experiments were conducted at the Beltsville Agricultural Research Center, Beltsville, MD, in 1999 to 2001; the University of Maryland Lower Eastern Shore Research and Education Center, Salisbury, MD, in 1999; and the Cornell University Thompson Vegetable Research Farm, Freeville, NY, in 1999. Soils were a Matawan (fine-loamy, siliceous, semiactive, mesic Aquic Hapludults)-Hammonton (coarse-loamy, siliceous, semiactive, mesic Aquic Hapludults) loamy sand in 1999 and 2000 and an Elkton (fine-silty, mixed, active, mesic Typic Endoaquults)-Keport (fine, mixed, semiactive, mesic Aquic Hapludults) silt loam in 2001 at Beltsville. The soil at Salisbury was a Norfolk loamy sand (fine-loamy, kaolinitic, thermic Typic Kandiudults). The soil at Freeville was a Howard gravelly loam (loamy, skeletal, mixed, mesic Glossoboric Hapludalf). Salisbury (38°21′38′′ N, 75°35′59′′ W; 7 m elevation) is located near the Atlantic Coast and has the mildest climate of the three sites. Beltsville (39°02′05″N, 76°54′28″W; 35 m elevation) is farther inland near the fall line between the piedmont and coastal plain. Freeville (42°30′50″N, 76°20′49″W; 319 m elevation) is farthest north and inland and has the coldest climate of the three sites.

Three hairy vetch cultivars (AU Early Cover, Advanced Population 8, and Advanced Population 26) developed by J.A. Mosjidis, Auburn University, and C.M. Owsley, USDA-NRCS Plant Materials Center, GA, were compared with the unnamed hairy vetch commonly used by growers (designated as "common" in this paper). Seed of hairy vetch mixed with the appropriate inoculum were spread by hand at 28 kg ha^{-1} on a seedbed prepared by plowing, disking, and packing. The same seed lots were used at all sites in 1999. After seeding, a seeder was driven over all plots to pack the soil similarly as if performed mechanically. Two plantings were made at each location, an early planting that represented the estimated optimum time for planting hairy vetch at that location and a planting approximately 2 to 4 wk later that represented a delayed planting date (Table 1). Plots were 1.5 by 6.1 m with four replications. Treatments were arranged in a split-plot design with planting date as whole plot and cultivar as subplot.

Hairy vetch biomass was hand-clipped from one 1-m^2 quadrat per plot located in a representative area without weeds at two times. The first harvest was conducted at the time no-tillage corn typically is planted at the location. The second harvest was conducted when hairy vetch was in full bloom, resulting in a range of harvest dates depending on the flowering phenology of each cultivar (Table 1). Hairy vetch samples were dried for mass determination, and the ground tissue was analyzed for N concentration with a LECO CHN-600 Analyzer (LECO Corp., St. Joseph, MI). Percentage of soil covered by hairy vetch was estimated visually by at least two raters in late fall and at approximately weekly intervals from April through June. Visual survival estimates were recorded in April at Freeville where significant winterkill occurred. Percentage flowering estimates were made at Beltsville and Salisbury, and percentage senescence estimates were made at Beltsville at the same time as the cover ratings. The Julian date on which 50% flowering and 50% senescence occurred was determined by linear interpolation between the bracketing dates for each plot, and these dates were used for analysis.

Analysis of variance was performed with experiment, planting date, cultivar, and harvest date as fixed effects and block and appropriate split-plot error terms within experiment as random effects. Growing degree days were computed for each day as the average air temperature minus 4°C. (The true average temperature was determined at Beltsville and Freeville, whereas the average of the recorded maximum and minimum temperatures was determined at Salisbury.) Cumulative GDD were determined for intervals between planting and the date of fall cover ratings, biomass sampling, 50% flowering, and 50% senescence. Regression analysis of fall cover ratings and biomass as a function of GDD was performed for each cultivar. Analysis of covariance was performed, with cultivar as a class variable and GDD as a regression variable, to determine interactions between cultivar and GDD. Because of abnormally low rainfall in fall and poorly drained soil conditions in winter and spring in the 2001 Beltsville experiment, data from this experiment were not included in determinations of GDD to biomass or 50% flowering.

RESULTS AND DISCUSSION

Biomass

Hairy vetch suffered significant winterkill at Freeville, NY. All Auburn cultivars at both planting dates had 21 to 36% survival, whereas survival of common hairy vetch was 85% when planted early but 39% when planted late. The absolute minimum air temperature at

Table 1. Planting and harvesting dates of hairy vetch cultivars at Freeville, NY; Salisbury, MD; and Beltsville, MD.

Operation	Timing	Freeville 1998–1999	Salisbury 1998–1999	Beltsville 1998–1999	Beltsville 1999–2000	Beltsville 2000–2001
Planting	early	25 Aug.	1 Oct.	21 Sept.	28 Sept.	2 Oct.
	late	14 Sept.	14 Oct.	13 Oct.	27 Oct.	24 Oct.
Harvesting	vegetative	10 May	20 Apr.	4 May	2–4 May	None
	flowering	28 May–4 June	7–26 May	18 May–1 June	17–24 May	22 May–11 June

Table 2. Analysis of variance for hairy vetch biomass and N concentration as influenced by experiment, planting date, cultivar, and harvest date.

Effect	Biomass	N concentration
	Probability > F	
Experiment (E)	0.0001***	0.0001***
Planting date (P)	0.0001***	0.1003
E × P	0.0001***	0.0001***
Cultivar (C)	0.0001***	0.4841
E × C	0.0011**	0.0141*
P × C	0.0289*	0.5238
E × P × C	0.0416*	0.0040**
Harvest date (H)	0.0001***	0.0001***
E × H	0.0001***	0.3141
P × H	0.0001***	0.4035
E × P × H	0.2835	0.4625
C × H	0.4016	0.2544
E × C × H	0.1584	0.0206*
P × C × H	0.3476	0.1488
E × P × C × H	0.1738	0.3402

* Significant at the 0.05 probability level.
** Significant at the 0.01 probability level.
*** Significant at the 0.001 probability level.

Table 4. Hairy vetch biomass for the experiment × harvest date interaction and for the planting date × harvest date interaction.

Experiment	Planting date	Biomass when harvested	
		Vegetative†	Flowering†
		g m^{-2}	
Freeville 1999	–	170	365
Salisbury 1999	–	349	667
Beltsville 1999	–	454	543
Beltsville 2000	–	292	429
Beltsville 2001	–	–‡	170
–	early§	404	555
–	late	229	446

† Vegetative indicates harvest at the time of typical corn planting; hairy vetch ranged from completely vegetative to partial flowering. Flowering indicates full bloom. All biomass values for hairy vetch harvested at flowering were significantly higher ($P = 0.05$) than corresponding values when harvested vegetative.
‡ There was insufficient hairy vetch biomass to harvest in early May of 2001 at Beltsville.
§ All biomass values for hairy vetch planted early were significantly higher ($P = 0.05$) than corresponding values when planted late.

Freeville was −20°C during a period in late December with trace snow cover and was −25°C in January when there was snow cover. Average minimum temperature during January was −13°C. In contrast, there was only superficial winter injury to foliage in Maryland where winter conditions were similar in all experiments. Absolute minimum temperatures ranged from −11 to −13°C, and average minimum temperatures in January ranged from 0 to −4°C in the Maryland experiments. These data are consistent with reports in the literature. Jannink et al. (1997) observed low hairy vetch survival at average minimum January temperatures of −14 and −16°C in Maine, particularly when there was little snow cover. Brandsæter et al. (2002) reported that 'Welta' hairy vetch survived exposure to −10°C, but AU Early Cover survival and recovery was reduced at −8°C. In summary, all cultivars of hairy vetch appear to survive average minimum temperatures to −4°C; common hairy vetch is more winter hardy than the Auburn cultivars at lower temperatures, but common hairy vetch becomes sensitive when planted late and exposed to average minimum temperatures below −10°C.

There were significant experiment × planting date × cultivar interactions for both hairy vetch biomass and N concentration (Table 2). Biomass of common hairy vetch was similar to or higher than biomass of all Auburn cultivars at both planting dates in all experiments (Table 3). Biomass of common hairy vetch was higher than that of all Auburn cultivars in the Freeville and 2000 Beltsville early plantings, Early Cover and Population 26 in the 2001 Beltsville early planting, and Population 8 in the 1999 and 2000 Beltsville late plantings.

Table 3. Hairy vetch biomass and N concentration as influenced by experiment, cultivar, and early or late planting date averaged across harvest dates.

Experiment	Cultivar	Biomass†		N†	
		Early planted	Late planted	Early planted	Late planted
		g m^{-2}		%	
Freeville 1999	common	430 a	307 a	3.5 a	3.3 c
	AU Early Cover	229 b	255 a	3.6 a	3.7 b
	Population 8	158 b	281 a	3.5 a	4.2 a
	Population 26	227 b	251 a	3.8 a	3.4 bc
Salisbury 1999	common	641 a	399 a	—	—
	AU Early Cover	579 a	422 a	—	—
	Population 8	582 a	423 a	—	—
	Population 26	582 a	438 a	—	—
Beltsville 1999	common	562 a	435 a	3.4 a	3.2 a
	AU Early Cover	557 a	422 ab	3.0 ab	3.1 a
	Population 8	588 a	345 b	3.1 ab	2.9 a
	Population 26	636 a	441 a	2.9 b	3.1 a
Beltsville 2000	common	569 a	297 a	3.4 a	3.6 a
	AU Early Cover	473 b	227 ab	2.9 b	3.4 a
	Population 8	375 c	170 b	3.0 b	3.4 a
	Population 26	484 b	286 a	3.0 b	3.3 a
Beltsville 2001	common	302 a	128 a	2.6 b	2.1 a
	AU Early Cover	190 b	95 a	3.1 a	1.9 a
	Population 8	234 ab	96 a	3.1 a	1.9 a
	Population 26	212 b	106 a	3.1 a	1.9 a

† Cultivar values followed by the same letter within experiment and planting date are not significantly different ($P = 0.05$). All biomass values for the early planting date were significantly different than the corresponding value for the late planting date within cultivar for all experiments except at Freeville where the difference was only significant for common hairy vetch and Population 8. Nitrogen comparisons between planting date within cultivar were significantly different for Population 8 at Freeville, Early Cover and Population 8 at Beltsville in 2000, and all cultivars at Beltsville in 2001.

There were no differences in biomass among Auburn cultivars, except Population 8 was lower than Early Cover and Population 26 in the 2000 Beltsville early planting and Population 26 in the 1999 and 2000 Beltsville late plantings.

There were significant experiment × harvest date and planting date × harvest date interactions for hairy vetch biomass but no significant interactions between cultivar and harvest date (Table 2). Hairy vetch biomass was higher when harvested at flowering than when vegetative in all experiments (Table 4). Relatively low biomass at the vegetative harvest at Freeville corresponded with winter injury and relatively cooler temperatures through April at this location. Absence of measurable biomass at the vegetative stage and low biomass at flowering at Beltsville in 2001 are related to droughty conditions in October and November (36 mm of total rain for these months) that delayed establishment of hairy vetch and poorly drained soils that remained saturated after winter rains. The planting date × harvest date interaction (Table 4) showed that delayed planting decreased hairy vetch biomass more when harvested in the vegetative stage (43%) than in the flowering stage (20%).

Variations in hairy vetch biomass across experiments, planting dates, and harvest dates could be explained by differences in GDD between planting and harvest. Biomass of common hairy vetch increased linearly as GDD increased (Fig. 1). Regression analyses showed similar slopes for all cultivars (common, AU Early Cover, Population 8, and Population 26 increased 41, 46, 46, and 54 g m^{-2} for every 100 GDD increase, respectively). An analysis of covariance of hairy vetch biomass as a function of cultivar as a class variable and GDD as a regression variable showed no significant interaction between cultivar and GDD (P = 0.854). This result confirmed that there were no significant differences between the slopes of biomass per GDD among cultivars.

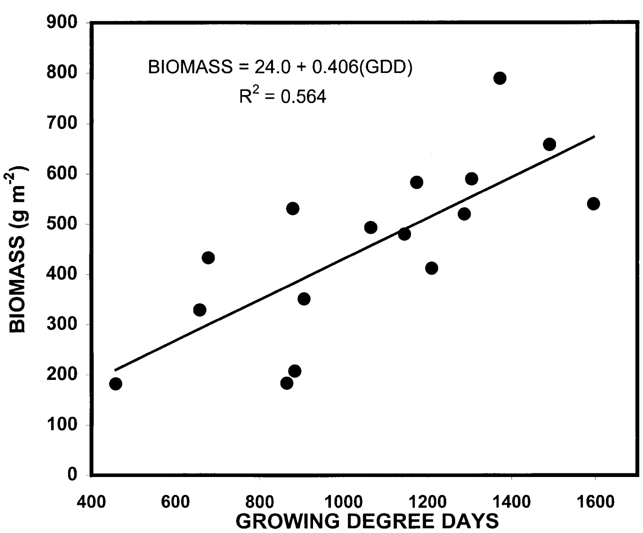

Fig. 1. Common hairy vetch biomass as a function of growing degree days (GDD) accumulated from planting date to harvest date computed using all planting and harvest dates at Freeville, NY, Salisbury, MD, and Beltsville, MD, in 1999 and 2000.

Nitrogen Concentration

Although there were significant experiment × cultivar × planting date and experiment × cultivar × harvest date interactions (Table 2), N concentrations of all cultivars tended to be similar within all planting or harvest dates in all experiments. Nitrogen concentration of common hairy vetch was higher than that of Population 26 in the 1999 Beltsville early planting and higher than that of all Auburn cultivars in the 2000 Beltsville early planting (Table 3). However, N concentration of common hairy vetch was lower than that of all Auburn cultivars in the 2001 Beltsville early planting and was lower than Early Cover and Population 8 in the Freeville late planting. Generally, hairy vetch tended to have higher N concentration when harvested at the vegetative (3.6%) than flowering (3.0%) stage. Hairy vetch biomass production usually has a greater impact on total N production than N concentration (Wagger, 1989).

A primary reason for using hairy vetch as a cover crop is its capacity to provide most of the N requirement of succeeding crops. If hairy vetch has a N content of 3.0 to 3.6%, then a biomass of 400 g m^{-2} would produce 120 to 144 kg ha^{-1} N. This level of N production is sufficient to meet most of the requirements of corn or tomato (Decker et al., 1994; Abdul-Baki et al., 1997). According to the regression model in Fig. 1, an estimated 926 GDD would be needed following planting hairy vetch to achieve this biomass. A biomass of 400 g m^{-2} was achieved for all planting and harvesting dates, except when hairy vetch was planted late and harvested at the vegetative stage (Table 4). Since the timing of the vegetative harvest represented the time of corn planting, and one of the primary purposes of planting hairy vetch is to provide N for corn, these data suggest that hairy vetch should be planted sufficiently early to permit at least 926 GDD to accumulate before corn planting. If the planting date for the spring crop could be delayed until hairy vetch flowers, as may be the case for many vegetable crops, then hairy vetch planting could be delayed without adverse consequences.

Cover, Flowering, and Senescence

There was a significant interaction between experiment and planting date for hairy vetch soil cover in late fall, but there were no significant effects involving cultivar (Table 5). Soil cover in late fall only exceeded 50% in two of four experiments when hairy vetch was

Table 5. Analysis of variance for hairy vetch soil cover in late fall, 50% flowering, and 50% senescence dates as influenced by experiment, planting date, and cultivar.

Effect	Fall cover	Flowering	Senescence
	Probability > F		
Experiment (E)	0.0001***	0.0001***	0.0001***
Planting date (P)	0.0001***	0.0001***	0.0003***
E × P	0.0001***	0.0001***	0.9781
Cultivar (C)	0.6535	0.0001***	0.0001***
E × C	0.3197	0.0002***	0.0001***
P × C	0.8028	0.0121*	0.0180*
E × P × C	0.5362	0.0001***	0.1401

* Significant at the 0.05 probability level.
*** Significant at the 0.001 probability level.

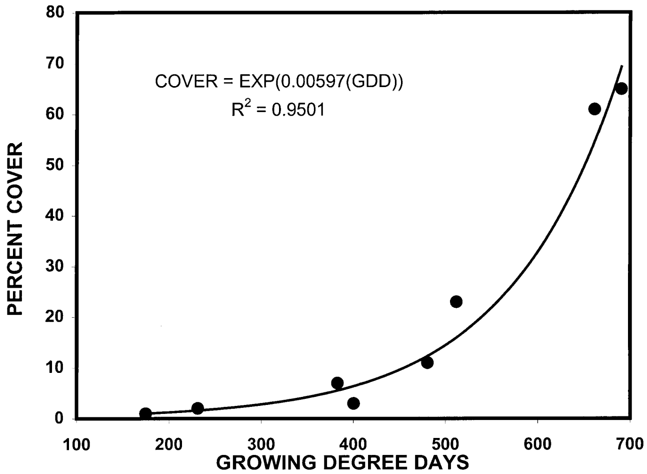

Fig. 2. Percent of soil covered by hairy vetch in late fall as a function of growing degree days (GDD) accumulated from early and late planting dates until 21 Dec., 1998 at Salisbury; 11 Dec., 1998 at Beltsville; 30 Nov., 1999 at Beltsville; and 4 Dec., 2000 at Beltsville. Data are averaged over cultivar since there were no significant cultivar effects on this variable.

planted early but was less than 12% in all experiments when hairy vetch was planted late. Between planting and late-fall cover ratings, 691 GDD were required to achieve 65% cover in the 1999 Beltsville experiment, and 662 GDD were required to achieve 61% cover in the Salisbury experiment. Soil cover was predicted by an exponential function of GDD after planting (Fig. 2). This model predicts that to achieve at least 50% soil cover before winter, hairy vetch needs to be planted so that a minimum of 655 GDD accumulate during the fall. Therefore, early planting is required to produce sufficient hairy vetch ground cover for adequate soil protection during winter.

There was a significant experiment × planting date × cultivar interaction for date of 50% flowering (Table 5). All Auburn cultivars flowered earlier than common hairy vetch at all planting dates (Table 6). Differences in flowering between AU Early Cover and common hairy vetch ranged from 8 to 23 d with a mean of 15 d. All Auburn cultivars flowered at similar dates, except Population 8 flowered earlier than the other two Auburn cultivars when planted early in the 2000 Beltsville experiment and earlier than AU Early Cover when planted late in the 2001 Beltsville experiment. Early plantings of hairy vetch flowered earlier than late plantings although this difference ranged from 1 to 22 d.

Our data as well as reports in the literature suggest that time of hairy vetch flowering is controlled less by photoperiod than by temperature. Hairy vetch has been reported to flower in late April in North Carolina (Wagger, 1989) and in mid- to late June in Norway (Brandsæter and Netland, 1999) and Maine (Jannink et al., 1997). Our data show 50% flower dates ranging from April to June (Table 6). Accumulated GDD between planting and 50% flowering were consistent, ranging from 1313 to 1398 and 1095 to 1205 for the early and late plantings of common hairy vetch, respectively, and from 1064 to 1161 and 937 to 962 for the early and late plantings of AU Early Cover, respectively. These results suggest that flowering is controlled primarily by temperature-dependent physiological processes. However, the slightly lower GDD required for flowering in late plantings of both cultivars suggests that local environmental conditions near the time of flowering can modify this process. Later-planted hairy vetch usually experienced warmer and/or drier soil conditions just before flowering that could have accelerated flowering compared with early planted hairy vetch.

Time to 50% senescence was earlier for all Auburn cultivars than common hairy vetch at both planting dates of the 2000 Beltsville experiment and the early planting date of the 2001 Beltsville experiment (Table 6). There was a trend toward earlier senescence with earlier than late planting dates, but few of these contrasts were significant. Growing degree days between 50% flowering and 50% senescence were relatively constant with a range of 351 to 561 and a mean of 475. There were no differences in flowering-to-senescence GDD between common and Auburn cultivars or between early and late plantings. The week preceding all senescence dates had temperatures exceeding 30°C and/or low rainfall, so it is difficult to distinguish whether senescence was

Table 6. Dates on which hairy vetch achieved 50% flowering and 50% senescence as influenced by experiment, cultivar, and early or late planting date.†

		Date of 50% flowering		Date of 50% senescence	
Experiment	**Cultivar**	**Early planted**	**Late planted**	**Early planted**	**Late planted**
Salisbury 1999	**common**	**13 May a**	**19 May a**	–	–
	AU Early Cover	**25 Apr. b**	**26 Apr. b**	–	–
	Population 8	**25 Apr. b**	**26 Apr. b**	–	–
	Population 26	**25 Apr. b**	**27 Apr. b**	–	–
Beltsville 1999	**common**	**20 May a**	**22 May a**	**8 June a**	**12 June a**
	AU Early Cover	**3 May b**	**9 May b**	**4 June a**	**8 June ab**
	Population 8	**3 May b**	**10 May b**	**5 June a**	**8 June ab**
	Population 26	**4 May b**	**9 May b**	**4 June a**	**8 June b**
Beltsville 2000	**common**	**13 May a**	**16 May a**	**16 June a**	**14 June a**
	AU Early Cover	**24 Apr. b**	**8 May b**	**28 May b**	**4 June b**
	Population 8	**15 Apr. c**	**7 May b**	**31 May b**	**4 June b**
	Population 26	**22 Apr. b**	**7 May b**	**30 May b**	**7 June b**
Beltsville 2001	**common**	**20 May a**	**1 June a**	**20 June a**	**21 June a**
	AU Early Cover	**7 May b**	**22 May b**	**14 June b**	**20 June a**
	Population 8	**7 May b**	**18 May c**	**14 June b**	**20 June a**
	Population 26	**8 May b**	**20 May bc**	**15 June b**	**18 June a**

† Cultivar values followed by the same letter within experiment and planting date are not significantly different (P = 0.05).

induced by temperature-dependent physiological processes or by the onset of stress conditions.

CONCLUSIONS

Common hairy vetch produced biomass equal to or higher than the Auburn cultivars under northeastern conditions. The Auburn cultivars flowered an average of 15 d earlier than common hairy vetch and were winter hardy under Maryland but not under New York conditions. Neither of the Auburn advanced populations performed better than AU Early Cover. Thus, common hairy vetch would be desirable for general use in the northeastern states, but AU Early Cover is an alternative for Maryland growers that desire a legume cover crop that flowers earlier than common hairy vetch.

Hairy vetch growth and development appears to depend on temperature and can be predicted on the basis of GDD with a base temperature of 4°C. To achieve 50% soil cover by hairy vetch vegetation in late fall before the onset of winter, 655 GDD were required. To achieve a hairy vetch biomass of 400 g m^{-2} (a reasonable target for providing most of the N requirements for high-N-requiring crops such as corn or tomato), 926 GDD were required. Delaying planting by 2 to 4 wk past optimum and killing hairy vetch while vegetative for early corn planting did not provide a sufficient number of GDD to achieve this biomass target at any location. If allowed to grow until flowering, both common and AU Early Cover hairy vetch would produce more than sufficient biomass to meet the N requirements of succeeding crops regardless of planting date.

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REFERENCES

Abdul-Baki, A.A., J.R. Teasdale, and R.F. Korcak. 1997. Nitrogen requirements of fresh-market tomatoes on hairy vetch and black polyethylene mulch. HortScience 32:217–221.

Brandsæter, L.O., and J. Netland. 1999. Winter annual legumes for use as cover crops in row crops in northern regions: I. Field experiments. Crop Sci. 39:1369–1379.

Brandsæter, L.O., A. Olsmo, A.M. Tronsmo, and H. Fykse. 2002. Freezing resistance of winter annual and biennial legumes at different developmental stages. Crop Sci. 42:437–443.

Brar, G.S., J.F. Gomez, B.L. McMichael, A.G. Matches, and H.M. Taylor. 1991. Germination of twenty forage legumes as influenced by temperature. Agron. J. 83:173–175.

Clark, A.J., A.M. Decker, J.J. Meisinger, F.R. Mulford, and M.S. McIntosh. 1995. Hairy vetch kill date effects on soil water and corn production. Agron. J. 87:579–585.

Creamer, N.G., and S.M. Dabney. 2002. Killing cover crops mechanically: Review of recent literature and assessment of new research results. Am. J. Alternative Agric. 17:32–40.

Decker, A.M., A.J. Clark, J.J. Meisinger, F.R. Mulford, and M.S. McIntosh. 1994. Legume cover crop contributions to no-tillage corn production. Agron. J. 86:126–135.

Jannink, J.L., L.C. Merrick, M. Liebman, E.A. Dyck, and S. Corson. 1997. Management and winter hardiness of hairy vetch in Maine. Tech. Bull. 167. Maine Agric. and Forest Exp. Stn., Univ. of Maine, Orono.

Mosjidis, J.A., C.M. Owsley, M.S. Lirkland, and K.M. Rogers. 1995. Registration 'AU Early Cover' hairy vetch. Crop Sci. 35:1509.

Mosjidis, J.A., and X. Zhang. 1995. Seed germination and root growth of several *Vicia* species at different temperatures. Seed Sci. Technol. 23:749–759.

Power, J.F., and J.A. Zachariassen. 1993. Relative nitrogen utilization by legume cover crop species at three soil temperatures. Agron. J. 85:134–140.

Teasdale, J.R., and R.C. Rosecrance. 2003. Mechanical versus herbicidal strategies for killing a hairy vetch cover crop and controlling weeds in minimum-tillage corn production. Am. J. Alternative Agric. 18:95–102.

Wagger, M.G. 1989. Time of desiccation effects on plant composition and subsequent nitrogen release from several winter annual cover crops. Agron. J. 81:236–241.

Zachariassen, J.A., and J.F. Power. 1991. Growth rate and water use by legume species at three soil temperatures. Agron. J. 83:408–413.